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Eretmocerus furuhashii sp. n. (Hymenoptera, Aphelinidae), a Parasite of *Parabemisia myricae* (KUWANA) (Homoptera, Aleyrodidae) in Japan

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Abstract *Eretmocerus furuhashii* sp. n., a parasite of the bayberry whitefly in Japan, is described and compared to the closely related *E. debachi* ROSE & ROSEN.
Key words: *Eretmocerus*; Aphelinidae; *Parabemisia*; Aleyrodidae; Japan.

Species of *Eretmocerus* HALDEMAN (Hymenoptera: Aphelinidae) develop as primary ecto-endoparasites of whitefly (Homoptera: Aleyrodidae) and are important natural enemies for biological control. The bayberry whitefly, *Parabemisia myricae* (KUWANA), is a native of Asia that was discovered on *Gardenia* and *Citrus* in southern California in 1978 (ROSE & DEBACH, 1991). Rapid spread of this whitefly posed a severe threat to commercial citrus groves in that region. Attempts at chemical control proved useless and brought about population upsets of various pests through destruction of natural enemies. As a result, a biological control program to import and establish parasites was initiated in 1979.

Parabemisia myricae was originally described from Japan as *Bemisia myricae* and attacks *Myrica rubra*, *Morus alba*, *Citrus* spp., and other plants (KUWANA, 1927). ISHII (1938) and IINO and MATSUTANI (1933) described and discussed parasites of *P. myricae* in Japan; thus a search for parasites was initiated on the islands of Shikoku and Honshu. Intensive surveys of sericulture mulberry groves with very low population levels of *P. myricae* yielded an unnamed species of *Eretmocerus*. This species was imported, cultured, and colonized in California citrus groves during 1979–81, where it quickly became established and began to reduce *P. myricae* populations. However, in 1982 an adventitious parasite, *Eretmocerus debachi* ROSE & ROSEN, was discovered attacking *P. myricae* in southern California (ROSE & ROSEN, 1991). *Eretmocerus debachi* proved to be very effective and completely displaced the *Eretmocerus* sp. imported from Japan, eventually providing complete biological control of the bayberry whitefly in southern California, and then in Israel and Turkey (ROSE & DEBACH, 1991; SWIRSKI *et al.*, 1988 a, b; UYGUN *et al.*, 1990). ROSE and DEBACH (1991) provide a complete account of the biological control of *P. myricae* in southern California.

The *Eretmocerus* imported from Japan is described below as a new species. It is named in honor of Kaichi Furuhashi, Chief of Biological Control Research at the

Shizuoka Citrus Research Station, Honshu, Japan, who was instrumental in the discovery of this species.

Measurements were acquired utilizing a digitizing tablet and ratios were calculated using the Statistical Analysis System® software (SAS Institute, 1985). Size of females was determined by measuring critical point-dried, card-mounted specimens through a dissecting microscope at a magnification of 157×. Because the values given in the text are approximate, qualifying terms such as "about" or "near" are not used. Values followed by a "+" or "−" indicate those values can be slightly higher or lower.

Eretmocerus furuhashii sp. n.

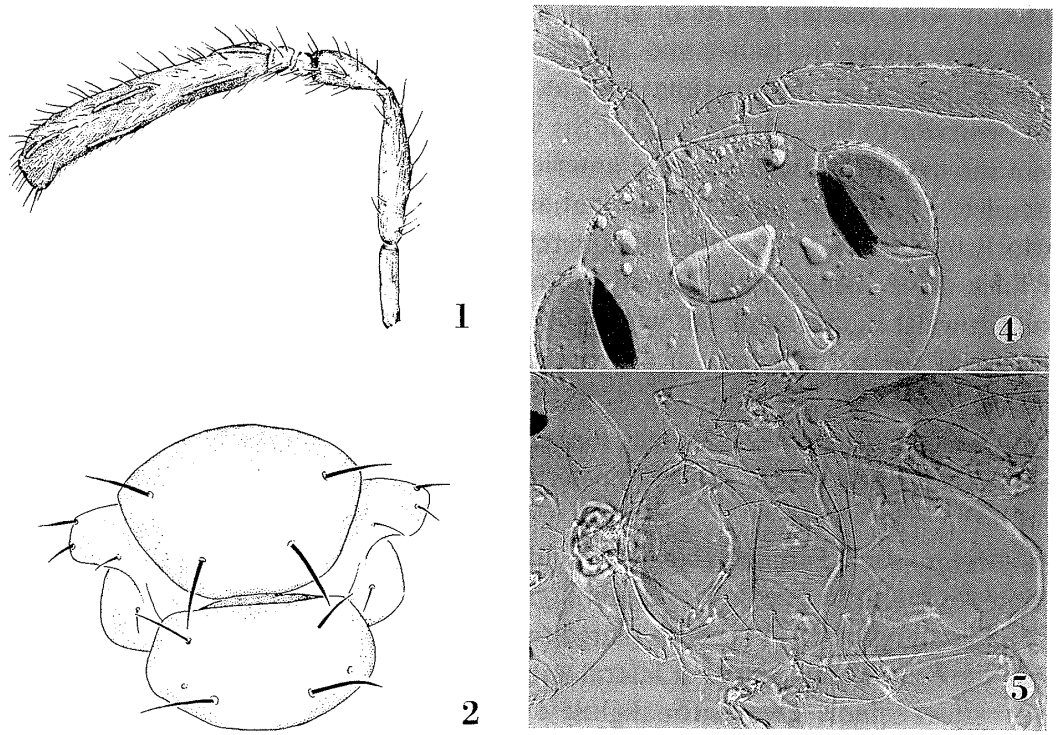
(Figs. 1–5)

Female. Length 0.46–0.53 mm, mean 0.49 (n=14). Body and antennae pale yellow, head whitish, eyes pale olive green, ocelli red. A color photograph of *E. furuhashii* appears in Figure 38 of Rose and DeBach (1991). Air-dried specimens uniformly pale yellow; eyes dark; ocelli red. Cleared, slide-mounted specimens colorless, except head and eyes.

Head. Face and occiput with transverse substrigulate sculpture, interscrobal area vertically substrigulate and with 10–13 setae between toruli. Eyes finely setose; ocelli forming an obtuse triangle. Mandible with 1 well-defined tooth and an elongate area with 3 weakly formed denticles; maxillary palpi and labial palpi 1-segmented.

Antenna composed of radicle, scape, pedicel, 2 funicle segments, and an unsegmented club (Figs. 1, 4). Radicle 4 times longer than wide; scape 4 times longer than wide, twice as long as radicle, and 0.6 length of club; pedicel 2.25 times longer than wide, equal in length to radicle and 0.5 length of scape; funicle I triangular, ventrally nearly as long as wide; funicle II 1.3 times wider than long; club clavate and apically deflexed, much narrower at the base than apex, 5 times longer than its greatest width (range 4.3–5.6), 3.6 times longer than radicle, 1.7 times longer than scape, 3.5 times longer than pedicel, 1.3 times longer than middle tibia, and with 10–15 multiporous plate sensilla (longitudinal sensilla).

Mesosoma. Pronotum divided, with 2 setae at each posterior dorsal corner. Mesoscutum trapezoidal, 1.5 times wider than long, anteriorly slightly wider than scutellum, posteriorly narrower than scutellum, with 4 setae and reticulate sculpture anteriorly and laterally, becoming weakly longitudinally substrigulate medially; each parapsis with 3 setae (Fig. 2) and reticulate-substrigulate sculpture; each axilla with 1 seta and sculpture similar to parapsides. Scutellum 1.9 times wider than long, with 4 setae, placoid (discoid) sensilla lateral to and closer to posterior setae than anterior setae, and with reticulate sculpture laterally and weak substrigulate sculpture medially. Propodeum reticulate at lateral margins, central lobe extending half way over metasomal tergite II; endophragma extending into



Figs. 1–5. *Eretmocerus furuhashii*. —— 1, ♀ antenna; 2, ♀ mesosoma with three setae on parapsis; 3, ♀ fore wing; 4, ♀ antenna; 5, ♂ dorsum, with pigment pattern on mesoscutum, scutellum, and metanotum.

tergite IV.

Fore leg formula (length femur: tibia: tarsi) 1: 0.8+: 1, tarsal formula (length tarsi 1: 2: 3: 4) 1: 0.6: 0.5: 0.4, fore tibial spur 0.8 basitarsus length; mid leg formula 1: 1.3: 1.1, tarsal formula 1: 0.5: 0.5: 0.4, mid tibial spur 0.6− basitarsus length; hind leg formula 1: 1.4−: 1.1−, tarsal formula 1: 0.65: 0.5+: 0.45, hind tibial spur 0.5− basitarsus length.

Fore wing hyaline, almond-shaped (Fig. 3), 2.5 times longer than its greatest width, longest anterior alary fringe 0.2+ width of disc, longest posterior alary fringe 0.5 width of disc, base of wing bare, costal cell dorsally with 3–4 setae along the

anterior wing margin at the origin of the marginal vein; submarginal vein with 3 large setae above the bullae and 1 large seta at distal end of bullae; marginal vein with 3 long setae, the proximal seta inserted near the origin of the marginal vein but posterior to the anterior edge of the wing, and the middle and distal setae larger than the first and inserted on the anterior edge of the wing; 9–14 setae between incomplete linea calva and submarginal and marginal veins, linea calva closed posteriorly by setae; a group of 10–18 tubercles on ventral surface beneath posterior end of linea calva; beneath and distad of linea calva a group of 17–26 (mean 22) setae point toward the front of the wing, the remaining 95–139 (mean 115) setae in the disc point toward the apex of the wing; length of submarginal: marginal: stigmal veins 1: 0.4: 0.3−.

Hind wing hyaline, 7.7 times longer than broad, longest anterior alary fringe 0.3+ times wing width, longest posterior alary fringe 1.4 times longer than wing width.

Metasoma. Tergite III with reticulate sculpture laterally and transverse substrigulate sculpture medially. Lateral margins of tergites IV–VIII imbricate with stippling; tergites III–VIII with paired setae as follows: 1, 1, 1–2, 2, 2, 1; syntergum with 4 setae. Cerci located at lateral anterior margin of syntergum, each with 2 long and 1 short setae. Ovipositor slightly exserted, 3.3+ times longer than radicle, 1.6 times longer than scape, 0.9 times club length, and 0.8 times length of middle tibia.

Male. Similar to female in size, differing in color and antennal structure. Habitus orange, but face yellow and portions of antennae, thorax, and wings fuscous. Specimens cleared and mounted in Hoyer's retain fuscous areas. Pedicel and club fuscous; mesoscutum faintly to darkly fuscous across the anterior margin and medially duscous to the posterior margin, forming a 'T' shape; anterior and posterior margins of scutellum fuscous, connected medially by fainter infuscation, lateral areas of scutellum unpigmented (Fig. 5); metanotum fuscous in middle 1/2–2/3; fore wing venation and proximal 1/2 of costal cell fuscous; hind wing venation fuscous.

Antenna composed of radicle, scape, pedicel, and a large unsegmented club bearing numerous multiporous plate sensilla. Radicle 4.4 times longer than wide; scape 4 times longer than wide, 1.6− times longer than radicle and 0.25 length of club; pedicel as long as greatest width, 0.45 length of radicle, 0.3− length of scape, club long and curved, widest proximally, 8.1+ times longer than its greatest width and 12.3− times as long as the narrowest width, 6.6 times longer than radicle, 4.2− times longer than scape, 14.6− times longer than pedicel, and 2.2 times longer than middle tibia.

Genitalia with aedeagus exserted and cleft at the tip, aedeagus 3.65 times longer than digiti; each digitus with a single large apical tooth and a subapical pore.

Material examined. Holotype ♀, "Japan: Shizuoka, Kochi, VIII. 1979, *Parabemisia myricae* (Kuwana) on *Morus*, M. Rose". Allotype ♂, "USA: CAL: Irvine, South Coast Field Station, XI. 10. 1982, *Parabemisia myricae* (Kuwana) on lemon, culture". Holotype and allotype mounted in Canada balsam on separate

slides and deposited in the National Science Museum, Tokyo, Japan.

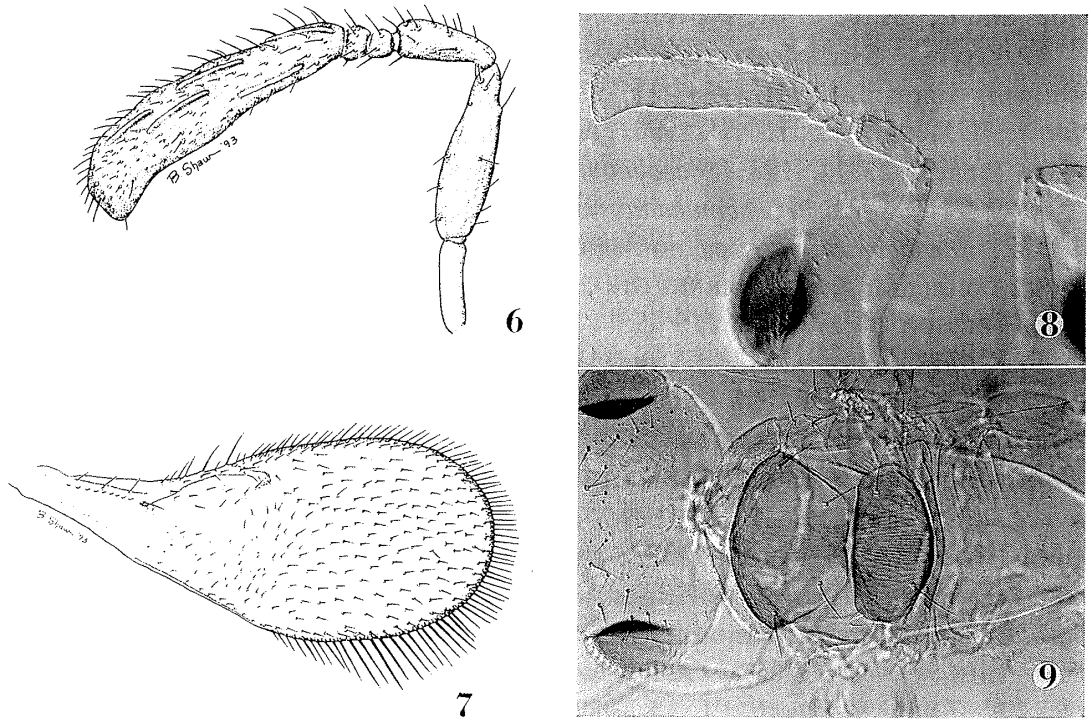
Paratypes. Same data as allotype, 7 ♀; same locality as allotype but with the following dates: 28. VIII. 1982, 17 ♀; XI. 3. 1982, 4 ♀; 4. XI. 1982, glasshouse culture, M. ROSE, 3 ♀; 15. XII. 1982, glasshouse culture, S. KEY, 20 ♀; Orange Co., Irvine Ranch, 23. IX. 1981, *Parabemisia myricae* on lemons, ROSE, FERRENTINO, 6 ♀, 8 ♂; VI. 9. 1982, *Parabemisia myricae* on lemons, ROSE, FERRENTINO, 1 ♀; VI. 19. 1982, *Parabemisia myricae* on lemons, ROSE, 6 ♀; VI. 21. 1982, *Parabemisia myricae* on lemon, ROSE, FERRENTINO, 2 ♀; VII. 29. 1982, *Parabemisia myricae* on lemon, FERRENTINO, WOOLLEY, 9 ♀, 1 ♂; 4. XI. 1982, *Parabemisia myricae* on lemons, ROSE, FERRENTINO, 1 ♂; Irvine Lath House, X. 9. 1981, *Parabemisia myricae* on citrus, ROSE, 9 ♀, 1 ♂; Riverside Co., Corona, Foothill Ranch, 31. VIII. 1981, *Parabemisia myricae* on lemons, ROSE, FERRENTINO, 9 ♀, 2 ♂; 20. IV. 1982, *Parabemisia myricae* on lemons, ROSE, FERRENTINO, 3 ♀, 1 ♂; V. 15. 1982, *Parabemisia myricae* on lemons, ROSE, FERRENTINO, 1 ♀; VII. 29. 1982, *Parabemisia myricae* on lemon, FERRENTINO, WOOLLEY, 20 ♀; Ventura Co., Ranch Todos Santos, VIII. 10. 1982, *Parabemisia myricae* on lemon, FERRENTINO, WOOLLEY, 3 ♀; 25. X. 1982, *Parabemisia myricae* on lemons, ROSE, FERRENTINO, 8 ♀; FILLMORE, 10. II. 1983; *Parabemisia myricae*, Coop. Glasshouse Eret. Culture, WOOLLEY, FERRENTINO, 42 ♀, 2 ♂; Fairview Ranch, IX. 15. 1982, *Parabemisia myricae*, ROSE, FERRENTINO, 2 ♀; IX. 23. 1982, *Parabemisia myricae*, ROSE, FERRENTINO., 2 ♀; San Gabriel, Ca., 524 Milton, IV. 22. 1982, *Parabemisia myricae* on orange, ROSE, FERRENTINO, 2 ♀; Japan, Mixed geo., *Parabemisia myricae* on orange, ROSE, 5 ♀.

Paratypes slide-mounted in Canada balsam or Hoyer's medium and deposited in the U.S. National Museum, Washington, D.C., USA; The Hebrew University, Rehovat, Israel; The Natural History Museum, London, United Kingdom; Texas A & M University Insect Collection, College Station, Texas, USA; and the National Science Museum, Tokyo, Japan.

Discussion. *Eretmocerus aleurolobi* ISHII is the only species of *Eretmocerus* previously described from Japan. The parasite was reared from *Aleurolobus marlatti* (QUAINTANCE) collected at Nagasaki in 1922, probably from citrus (ISHII, 1938). ISHII's specimens were housed in Nagasaki and were destroyed. Although ISHII's description of *E. aleurolobi* is brief and mostly generic, one outstanding character is given, the presence of four pairs of setae on the mesoscutum. This is unusual, and to date we have not seen this in series of other species of *Eretmocerus*. We trust ISHII was correct because he used this character to distinguish *E. aleurolobi* from *E. diversiciliatus* SILVESTRI.

One of us (ROSE) undertook collections of *A. marlatti* on citrus in Nagasaki in 1986 to obtain topotypical specimens of *E. aleurolobi*. The whitefly was easily found, but did not yield any specimens of *Eretmocerus*. Based on the single outstanding character of female *E. aleurolobi*, we are confident *E. furuhashii* cannot be *E. aleurolobi*. Future collections may eventually produce specimens of *E. aleurolobi*.

IINO and MATSUTANI (1933) depicted a species of *Eretmocerus*, along with an



Figs. 6–9. *Eretmocerus debachi* Rose & Rosen. —— 6, ♀ antenna; 7, ♀ fore wing; 8, ♀ antenna; 9, ♂ dorsum, with pigment pattern on mesoscutum, scutellum, and metanotum.

Amitus (Platygasteridae), as one of the parasites reared from *P. myricae* in Mie Prefecture, Japan. Their drawing is very similar to *E. furuhashii* and may illustrate that species, but no species name was given by those authors.

When originally discovered in Japan and imported to California, no male specimens of *E. furuhashii* were found. Viable laboratory cultures were created initially from a single parthenogenetic female. Later collections in Japan yielded a few males, as did glasshouse cultures in California. The males readily mated with virgin *E. furuhashii* females, and showed little or no interest in mated females. It is unknown if actual sperm transfer occurred in these matings.

This species is most likely to be confused with *E. debachi* Rose & Rosen, whose females have a shorter club (Figs. 6, 8), only 2 setae on each parapsis (as in Fig. 9), and a longer and wider fore wing (Fig. 7). Males of *E. debachi* have a similar but darker and more extensive 'T' shape on the mesoscutum, and the scutellum is completely darkened (Fig. 9). The distinct pigment patterns of male *E. furuhashii* and *E. debachi* are easily observed in live specimens. Male pigment has proven to be an important diagnostic character for species of *Eretmocerus* (Rose & Rosen, 1991).

Reciprocal crossing tests were conducted between these two species to test for reproductive isolation, and thus, the significance of male pigment patterns and morphological differences between females. Fully developed *E. furuhashii* and *E. debachi* pupae on citrus leaf bits from glasshouse cultures were isolated in 0.25 dram

vials and held at 28±1°C and 76–78% relative humidity for adult parasite emergence. Honey was provided for food and all adult parasites were held for 24–48 hours before mating tests. A male of the opposite species was introduced into each vial containing a single virgin female and their behavior was observed under a dissecting microscope. Opposite species males were replaced with conspecific males when mating was unsuccessful. In these tests, males showed no active interest in virgin females of the opposite species and there were no matings between *E. furuhashii* and *E. debachi*. In all replications (8 per species, 16 total), all conspecific mating tests were successful. Such biosystematic tests are of the utmost importance to the systematic study of groups such as *Eretmocerus*, as shown in earlier studies of *Aphytis* (ROSEN & DEBACH, 1979), where small, cryptic morphological differences may serve to characterize species.

Biological control. *Eretmocerus furuhashii* was found attacking *P. myricae* at very low population densities in mulberry groves in Japan. Based on examination of mummified whitefly, *E. furuhashii* appears to be active earlier in the spring growing season than the *Encarsia* species found attacking *P. myricae* during late summer in the same groves. An *Amitus* sp. apparently becomes active even earlier in the spring than *E. furuhashii* on uncultivated mulberry near Shizuoka, Honshu. Adult *Amitus* were collected only once, but mummified whitefly on older foliage provided evidence that this parasite generally was abundant in the Shizuoka environs during spring (ROSE, M., unpublished).

Eretmocerus furuhashii was readily cultured on rough lemon seedlings bearing *P. myricae* in a glasshouse in Orange County, California. The parasite preferred to oviposit under third stage whitefly larvae and fed on second stage larvae. Adult and immature *E. furuhashii* cultured on rough lemon seedlings were readily colonized and recovered in southern California citrus groves. Early field evaluations that measured dispersal, increased rates of parasitization and whitefly mortality, and additional whitefly mortality from host feeding indicated that *E. furuhashii* has excellent potential for achieving biological control of *P. myricae* (ROSE & DEBACH, 1991).

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